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PATENT SPECIFICATION

585,576

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PROVISIONAL SPECIFICATION

**Improvements in or relating to the Moulding of Lenses, Prisms
and like Optical Elements from Plastics**

I, JOHN JOHNSON, a British Subject, of Plasta Works, Bath Road, Slough, Buckinghamshire, do hereby declare the nature of this invention to be as follows:—

This invention consists of improvements in or relating to the moulding of lenses, prisms and like optical elements from plastics and has particular reference to the delicate and refined methods of ensuring correct optical properties in lenses and the like which are composed of clear transparent plastics and are moulded in hot moulds. The plastics referred to include methyl methacrylate polymer and polystyrene and they also include other clear, transparent, thermoplastic substances. Such material will hereinafter be referred to as "plastic".

Patent No. 416,398 describes a method of manufacturing optical lenses which consists in moulding to the required form between dies whose surfaces are highly polished at a temperature so low as not to injure the highly polished surface of the die a transparent material which is sufficiently plastic to be moulded at such a temperature.

Patent specification No. 556,743 describes a method for the production of lenses, prisms and like optical elements from transparent thermoplastic materials such as methyl methacrylate polymer or polystyrene in which a solid workpiece is preformed by cutting, grinding or like mechanical operations to a shape closely approximating to its final shape and the preformed workpiece is heated and then subjected to moulding in accurate dies to ensure that the element has the shape and surfaces of the optical accuracy demanded. That specification also describes apparatus for carrying out the final moulding step.

The present invention is applicable to the moulding of lenses, prisms and like optical elements, the surfaces of which have to be of optical precision, but the invention will be described in relation to the moulding of lenses.

If a preformed blank of plastic is of suitable shape and size in readiness for

the final moulding operation, the possibility of errors in moulding may arise from any of the following causes:—(a) The dies (generally of hardened steel) will be of different shape at the temperature at which the plastic solidifies from that which they attain at the temperature at which they were made. (b) The plastic will have a different size and shape at the temperature at which it solidifies from those it attains at the temperature at which it is used. (c) Distortion of the plastic may take place if the solidification of the plastic does not take place uniformly and simultaneously throughout its bulk.

It has been found in practice that any error due to change of shape of the dies can be readily allowed for if steps are taken to ensure that the dies are always heated and cooled in the same manner, preferably from their back surfaces, and also to ensure that during heating and cooling all parts of each back surface are kept at the same temperature.

In the same way the possibility of error under (b) can be readily dealt with if the same technique of heating and cooling is used consistently.

I have found that in certain cases the possibility of error referred to under (c) may have a definite and noticeable effect on the optical properties of the lens especially where one part of the lens is much thicker than another.

It will be appreciated that in the moulding of a flat disc with parallel sides if the die surfaces were isothermal and the sheet were of uniform thickness, no distortion would occur.

Considering next the moulding of a thick bi-convex lens, during the cooling, the centre portions of the metal dies will reach the solidifying temperature of the plastic before the peripheries of the dies do so (if the back surfaces of the dies are flat and are cooled isothermally) but as the plastic itself is a heat insulator the outer edge or periphery of the lens will solidify earlier than the central portion. Then during the solidification of the central portion (surrounded as it is by

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skin may occur.

Considering the moulding of a thick concave lens, the central portion of the lens will solidify before the periphery and distortion may occur.

Generally speaking steeply curved die surfaces militate against uniform cooling of the softened plastic. Owing to the high coefficient of expansion of the plastic, any errors or variations in the degree of preheating of the preformed plastic blank may tend to exaggerate the difficulties caused by unequal solidification of the thick plastic mass.

According to this invention the making of lenses, prisms and like optical elements from plastics by the general method of preheating the dies and preheating the pre-formed plastic blank and then moulding is characterised by the fact that only the outer layer or skin of the blank is preheated to the softening temperature so that the interior of any thick portion of the plastic blank remains solid during moulding and any movement or flow of plastic during moulding or solidification is confined to the outer layer or skin.

The nature of this invention and of subsidiary features thereof will be appreciated from the following description of specific examples of lens moulding.

A plastic blank is prepared by trepanning from plastic sheet a circular disc 3% less in diameter than the finished lens. The blank is then machined in a lathe with formed cutters so that the radius of each convex surface is 3% shorter than that in the finished lens (and so that the radius of each concave surface is 3% longer than that in the finished lens). The machined surfaces are then smoothed with fine emery paper while the blank is in the lathe. The shaped blank is then buffed to remove tool marks and give a smooth optical finish so that the blank can be easily and visibly cleaned before the moulding operation. The pre-formed blanks of plastic are carefully cleaned and are stored at a uniform temperature near the temperature at which the finished lenses will be used (for example they may be stored in a thermostat cabinet at 25° C. long enough to ensure that the blanks are uniformly at

that temperature).

The blanks are now placed in a thermostatically-controlled electric preheating oven for quite a short period (say 3 minutes). For blanks made of methyl methacrylate polymer a convenient temperature is 250° C. For blanks made from polystyrene a convenient temperature is 200° C. The effect of this short heating at these relatively high temperatures is to soften the outer layer or skin of the blank leaving the internal portion solid.

The dies are heated at the same time to the moulding temperature, say 130° C. for methyl methacrylate polymer and 120° C. for polystyrene. It is convenient to synchronise the heating of the dies with the preheating of the lenses so that the dies are at the correct moulding temperature when the blank is removed from the preheating oven. Each blank is then transferred to the heating dies, the press is closed, the pressure applied to effect the moulding and the cooling is allowed to take place not more rapidly than at the rate of 15° C. per minute. In the operation described regularity and consistency of technique are important: thus the transference of the blanks from the oven to the press must be done as quickly as possible and the actual time taken for the transfer and for the closing of the press should be kept the same for successive operations.

A safe temperature to remove the finished lenses from the press is 50° C. It is found that in the conditions above described the depth of the outer layer of plastic which is heated to a temperature above the softening point is about 1.5 mm. so that independently of the shape of the lens the material which undergoes actual moulding is equivalent to a plane flat sheet 3 mm. thick and any distortion due to the fact that the softened plastic does not solidify simultaneously throughout its bulk is therefore practically eliminated.

Dated this 6th day of September, 1943.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to the Moulding of Lenses, Prisms and like Optical Elements from Plastics

105 I, JOHN JOHNSON, a British Subject, of Plasta Works, Bath Road, Slough, Buckinghamshire, do hereby declare the

nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained 110

in and by the following statement:—

This invention consists of improvements in or relating to the moulding of lenses, prisms and like optical elements 5 from plastics and has particular reference to the delicate and refined methods of ensuring correct optical properties in lenses and the like which are composed of clear transparent plastics and are moulded 10 in hot moulds. The plastics referred to include methyl methacrylate polymer and polystyrene and they also include other clear, transparent, thermoplastic substances. Such material will hereinafter 15 be referred to as "plastic".

Patent No. 416,398 describes a method of manufacturing optical lenses which consists in moulding to the required form, 20 between dies whose surfaces are highly polished, and at a temperature so low as not to injure the highly polished surface of the die, a transparent material which is sufficiently plastic to be moulded at such a temperature.

25 Patent specification No. 556,743 describes a method for the production of lenses, prisms and like optical elements from transparent thermoplastic materials such as methyl methacrylate polymer or 30 polystyrene in which a solid workpiece is preformed by cutting, grinding or like mechanical operations to a shape closely approximating to its final shape and the preformed workpiece is heated and then 35 subjected to moulding in accurate dies to ensure that the element has the shape and surfaces of the optical accuracy demanded. That specification also describes apparatus for carrying out the final moulding 40 step.

The present invention is applicable to the moulding of lenses, prisms and like optical elements, the surfaces of which have to be of optical precision, but the 45 invention will be described in relation to the moulding of lenses.

If a preformed blank of plastic is of suitable shape and size in readiness for the final moulding operation, the 50 possibility of errors in moulding may arise from any of the following causes:—(a) The dies (generally of hardened steel) will be of different shape at the temperature at which the plastic solidifies from 55 that which they attain at the temperature at which they were made. (b) The plastic will have a different size and shape at the temperature at which it solidifies from those it attains at the temperature at which 60 it is used. (c) Distortion of the plastic may take place if the solidification of the plastic does not take place uniformly and simultaneously throughout its bulk.

It has been found in practice that any 65 error due to change of shape of the dies

can be readily allowed for if steps are taken to ensure that the dies are always heated and cooled in the same manner, preferably from their back surfaces, and also to ensure that during heating and 70 cooling all parts of each back surface are kept at the same temperature.

In the same way the possibility of error under (b) can be readily dealt with if the same technique of heating and cooling 75 is used consistently.

I have found that in certain cases the possibility of error referred to under (c) may have a definite and noticeable effect 80 on the optical properties of the lens especially where one part of the lens is much thicker than another.

It will be appreciated that in the moulding of a flat disc with parallel sides if the die surfaces were isothermal and 85 if the sheet were of uniform thickness, no distortion would occur.

Considering next the moulding of a thick bi-convex lens, during the cooling, 90 the centre portions of the metal dies will reach the solidifying temperature of the plastic before the peripheries of the dies do so (if the back surfaces of the dies are flat and are cooled isothermally) but as the plastic itself is a heat insulator the 95 outer edge or periphery of the lens will solidify earlier than the central portion. Then during the solidification of the central portion (surrounded as it is by the solidified periphery) distortion may occur. 100

Considering the moulding of a thick concave lens, the central portion of the lens will solidify before the periphery and distortion may occur.

Generally speaking steeply curved die 105 surfaces militate against uniform cooling of the softened plastic. Owing to the high coefficient of expansion of the plastic, any errors or variations in the degree of preheating of the preformed 110 plastic blank may tend to exaggerate the difficulties caused by unequal solidification of the thick plastic mass.

According to this invention the making 115 of lenses, prisms and like optical elements from plastics by the general method of preheating the dies and preheating the pre-formed plastic blank and then moulding is characterised by the fact that only the outer layer or skin of the blank is 120 preheated to the softening temperature so that the interior of any thick portion of the plastic blank remains solid during moulding and any movement or flow of plastic during moulding or solidification 125 is confined to the outer layer or skin.

The nature of this invention and of subsidiary features thereof will be appreciated from the following description of specific examples of lens moulding. 130

1 ns. The blank is then machined in a
6 lathe with formed cutters so that the
radius of each convex surface is 3%
shorter than that in the finished lens (and
so that the radius of each concave surface
is 3% longer than that in the finished
10 lens). The machined surfaces are then
smoothed with fine emery paper while the
blank is in the lathe. The shaped blank
is then buffed to remove tool marks and
give a smooth optical finish so that the
15 blank can be easily and visibly cleaned
before the moulding operation. The pre-
formed blanks of plastic are carefully
cleaned and are stored at a uniform tem-
perature near the temperature at which
20 the finished lenses will be used (for ex-
ample they may be stored in a thermostat
cabinet at 25° C. long enough to ensure
that the blanks are uniformly at that
temperature).

25 The blanks are now subjected for quite
a short period to externally applied heat,
for example, they are placed in a thermo-
statically-controlled electric preheating
30 oven for quite a short period (say 3
minutes). For blanks made of methyl
methacrylate polymer a convenient tem-
perature is 250° C. For blanks made
35 from polystyrene a convenient tempera-
ture is 200° C. The effect of this short
heating at these relatively high tempera-
tures is to soften the outer layer or skin
of the blank leaving the internal portion
40 solid.

40 The dies are heated at the same time
to the moulding temperature, say 130° C.
for methyl methacrylate polymer and
120° C. for polystyrene. It is convenient
45 to synchronise the heating of the dies
with the preheating of the lenses so that
the dies are at the correct moulding
temperature when the blank is removed
50 from the preheating oven. Each blank
is then transferred to the heated dies,
the press is closed, the pressure applied to
effect the moulding and the cooling is
55 allowed to take place not more rapidly
than at the rate of 15° C. per minute.
In the operation described regularity and
consistency of technique are important:
60 thus the transference of the blanks from
the oven to the press must be done as
quickly as possible and the actual time
taken for the transfer and for the closing
of the press should be kept the same for
65 successive operations.

65 A safe temperature to remove the
finished lenses from the press is 50° C.
It is found that in the conditions above
described the depth of the outer layer of
plastic which is heated to a temperature

actual moulding is equivalent to a plane
flat sheet 3 mm. thick and any distortion
due to the fact that the softened plastic
does not solidify simultaneously through-
out its bulk is therefore practically
eliminated.

70 In the described example of a method
75 embodying this invention the short
application of external heat to the sur-
faces of the plastic blank was effected in
an oven.

80 In an alternative method the short
application of external heat to the sur-
faces of the plastic blank may be
effected through the dies themselves as
described in Specification No. 1581/44
85 (Serial No. 572,748).

90 Having now particularly described and
ascertained the nature of my said inven-
tion and in what manner the same is to
be performed, I declare that what I claim
is:—

95 1. Method of making lenses and like
optical elements from plastics by pre-
heating the dies and the preformed plastic
blank and then moulding characterised
100 by the fact that only the outer layer or
skin of the blank is preheated to the
softening temperature so that the in-
terior of any thick portion of the plastic
blank remains solid during moulding
105 and any movement or flow of plastic
during moulding or solidification is con-
fined to the outer layer or skin.

110 2. A method of moulding optical
lenses from plastics in which a preformed
blank of plastic is subjected for quite a
short period (say 3 minutes) to externally
115 applied heat to soften only the outer
layer or skin of the blank leaving the
internal portion solid after which the
blank is moulded between optically
120 accurate dies and allowed to solidify by
slow cooling of said dies while the die
pressure is maintained.

125 3. A method as claimed in Claim 2 in
which the preformed blank is introduced
for a short period into an electric pre-
heating oven at a temperature well above
the softening temperature (e.g. 250° C.
130 for blanks made of methyl methacrylate
polymer or 200° C. for blanks made of
polystyrene).

135 4. A method as claimed in Claim 2 in
which the preformed blank is subjected
for a short period to externally applied
heat by being gently gripped between the
140 dies which are themselves temporarily
heated to a temperature well above the
softening temperature of the plastic.

145 5. A method of moulding optical
lenses from plastics as claimed in Claim 130

2 or 3 or 4, in which (a) a plastic blank is prepared by trepanning from plastic sheet a circular disc about 3% less in diameter than the finished lens, (b) the **5** blank is machined and ground in a lathe so that the radius of each convex surface is about 3% shorter than that in the finished lens (and so that the radius of each concave surface is 3% longer than

that in the finished lens) and (c) the heating and moulding operations take place:

6. The complete method for the moulding of lenses substantially as described.

Dated this 6th day of September, 1944.

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